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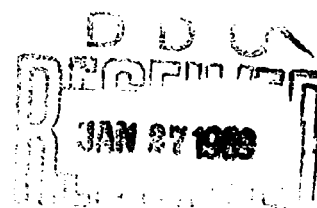
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**THE EFFECTS OF THE RIOT CONTROL AGENT
CS ON VISUAL ACUITY**

by

Roy H. Rengstorff, N.AJ, MSC

December 1968



**DEPARTMENT OF THE ARMY
EDGEWOOD ARSENAL
Research Laboratories
Medical Research Laboratory
Edgewood Arsenal, Maryland 21010**

EDGEWOOD ARSENAL TECHNICAL REPORT

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Experimental Medicine Department**

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Task 1B522301A07908

**DEPARTMENT OF THE ARMY
EDGEWOOD ARSENAL
Research Laboratories
Medical Research Laboratory
Edgewood Arsenal, Maryland 21010**

FOREWORD

The work described in this report was authorized under Task IB522301A07908, Non-Defense Medical Aspects of Chemical Agents, Incapacitating and Riot Control Agents (U). The work was started in April 1968 and completed in May 1968.

The volunteers in these tests are enlisted US Army personnel. These tests are governed by the principles, policies, and rules for medical volunteers as established in AR 70-25.

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DIGEST

Visual acuity measurements were taken on 66 male volunteers before and after exposure to (*o*-chlorobenzylidene)malononitrile (CS); 22 of these men were also tested during exposure to CS. The concentration varied from 0.1 to 6.7 mg/cu m, and the duration of exposure ranged from 20 seconds to 10 minutes.

The results of this study indicate that there is no appreciable change in visual acuity after exposure to CS. During exposure to low concentrations, all subjects can, with considerable effort, open their eyes for a few seconds. Their visual acuity decreases slightly. During exposure to concentrations higher than 5.0 mg/cu m, eye irritation is intense and most subjects cannot keep their eyes open for even a few seconds.

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THE EFFECTS OF THE RIOT CONTROL AGENT CS ON VISUAL ACUITY

I. INTRODUCTION.

One of the effects of (*o*-chlorobenzylidene)malononitrile (CS) is intense eye irritation. Human subjects close their eyes almost immediately when exposed to this riot control agent; they lacrimate profusely and show marked injection of the conjunctivae. However, the effects on visual acuity have never been studied. The present investigation was conducted to measure any changes in visual acuity during and after exposure to CS.

II. PROCEDURE.

A. An Orthorater (Bausch & Lomb Vision Tester) was used to measure the binocular far and near visual acuity of 10 male volunteers before and after exposure to CS-2 (CS treated with Cab-o-sil 5 and hexamethyldisilazane). The test targets were "signboards" of decreasing sizes, and the subjects were required to describe the location of checkerboard patterns on each signboard. After baseline visual acuity measurements were taken on each volunteer, he was brought to a specially designed wind tunnel. The 3-foot-square tunnel was 20 feet long and was suspended 4.5 feet above the floor. A Metronics powder dispenser disseminated specific concentrations of CS-2 in particle sizes of 0.8 micron mass median diameter at a wind speed of 4.5 miles per hour into one end of the tunnel. At the opposite end, each volunteer sat on a chair and put his head through a rubber aperture into the wind tunnel. He kept his head in the tunnel until he could no longer tolerate the agent or for a maximum of 10 minutes. The men were observed through the transparent sides of the tunnel. Within a few minutes of their withdrawal, the visual acuity test was repeated.

B. The Orthorater was also used to measure the binocular far and near visual acuity of 34 additional volunteers before and after exposure to CS. Instead of individual exposures in the wind tunnel, groups of two to four men donned protective masks and entered a specially designed, circular, steel chamber. The chamber was 10 feet high and 8 feet in diameter, with a large glass window and a number of smaller circular windows through which the subjects could be observed. CS aerosols were thermally disseminated from a methylene dichloride solution by introducing measured amounts into a thermal generator. The mass median diameter of the aerosols was 0.9 micron. The agent was then drawn into the dynamic exposure chamber as a uniform cloud. After the volunteers had been in the chamber for 5 minutes, they were told to remove their masks. They remained in the chamber for another 10 minutes unless they found the agent intolerable and left sooner. Within a few minutes of their exit, the visual acuity test was repeated.

C. A Snellen visual acuity projector was used to measure the binocular visual acuity of another 22 volunteers before, during, and a few minutes after exposure to CS. Only volunteers who had a baseline acuity of 20/20 with each eye were tested. The exposure procedure was identical to (B) above; however, just before leaving the chamber each man was instructed to look through a perforated circular plastic window at a projected Snellen chart, 20 feet from the window. The volunteer was asked to call out the smallest letters he could see. The chart contained a row of 20/30, 20/25, and 20/20 letters. Only those who remained in the chamber for 10 minutes were included in this procedure.

Throughout the above procedures the temperature was 70° to 80°F and the relative humidity was 40 to 50%.

III. RESULTS.

The changes in visual acuity after wind tunnel exposure to various concentrations of CS-2 for different periods of time are listed in table I.

Table I. CS-2 Concentration, Exposure Time, and Change in Far and Near Visual Acuity After Exposure in Wind Tunnel

Volunteer	CS-2 Concentration mg/cu m	Exposure Time seconds	Change in Orthorater Scores	
			Far	Near
1	0.1	20	-2	+1
2	0.1	55	-1	-2
3	0.1	225	0	0
4	0.1	600	-2	0
5	0.1	600	0	0
6	0.1	600	0	0
7	1.3	60	0	0
8	1.6	33	0	0
9	1.6	30	+2	+1
10	1.7	26	0	0

The changes in visual acuity after chamber exposure to various concentrations of CS for different periods of time are listed in table II.

The changes in Orthorater scores listed in tables I and II range from +2 to -2 for both far and near visual acuity. The mean change in far visual acuity of -0.4 and in near visual acuity scores is +0.4. There does not appear to be any appreciable difference between visual acuity of the men exposed in the wind tunnel and those exposed in the chamber. There is also no apparent relationship between changes in visual acuity scores and CS or CS-2 concentration, or exposure time.

These changes in Orthorater scores correspond to very small changes in visual acuity. This can be seen by comparing the range of raw scores found in this study with equivalent Snellen visual acuity:

Orthorater score	8	9	10	11	12
Snellen visual acuity	20/25	20/22	20/20	20/18	20/17

Table II. CS Concentration, Exposure Time, and Change in Far and Near Visual Acuity After Exposure in Chamber.

Volunteer	CS Concentration mg/cu m	Exposure Time seconds	Change in Orthorater Scores	
			Far	Near
1	0.4	135	+1	0
2	0.4	420	+2	0
3	0.4	435	0	0
4	0.4	600	0	-1
5	0.4	600	0	0
6	0.4	600	-2	0
7	0.4	600	+1	+1
8	0.6	30	0	0
9	0.6	35	-1	0
10	0.6	35	-1	0
11	0.6	38	0	+1
12	0.6	40	+1	+2
13	0.6	65	+1	0
14	0.6	68	-2	-1
15	0.6	102	-1	0
16	0.6	105	0	-1
17	0.6	165	0	0
18	0.6	600	0	0
19	0.6	600	0	0
20	0.6	600	-1	+1
21	0.6	600	+1	0
22	0.6	600	-1	+1
23	0.6	600	0	0
24	0.6	600	-1	-2
25	0.9	600	0	0
26	0.9	600	+2	-1
27	0.9	600	0	0
28	0.9	600	0	+1
29	0.9	600	0	0
30	0.9	600	+1	0
31	1.0	35	+1	0
32	1.0	40	-1	+1
33	1.0	45	-1	0
34	1.0	50	+2	0

The binocular far visual acuities during exposure to various concentrations of CS for 10 minutes of volunteers with baseline visual acuity of 20/20 with each eye are listed in table III.

Table III. CS Concentration, Exposure Time, and Far Visual Acuity During Exposure in Chamber

Volunteer	CS Concentration mg/cu m	Far Visual Acuity
1	0.5	20/20
2	0.5	20/20
3	0.5	20/25
4	0.5	20/30
5	0.5	20/20-
6	1.2	20/20
7	1.2	20/30
8	1.2	20/30-
9	1.2	20/30-
10	1.2	20/30-
11	2.5	20/30-
12	2.7	20/20
13	2.7	20/20
14	2.7	*
15	2.7	20/30
16	2.7	20/25
17	5.2	20/30-
18	5.2	*
19	5.2	*
20	5.2	*
21	5.2	*
22	6.7	*

*Could not open eyes long enough to see chart.

The visual acuity during exposure to CS ranged from 20/30- to 20/20. All volunteers had 20/20 acuity minutes after leaving the chamber.

IV. DISCUSSION.

During the exposure to CS either in the wind tunnel or in the chamber, all of the men had various degrees of respiratory and eye irritation. Some men felt the irritation to be so intolerable that they terminated their exposure after only a few minutes. In general, most men kept their eyes closed while exposed to the agent. They lacrimated profusely, and after leaving the wind tunnel or chamber they had marked conjunctival injection.

The small changes in visual acuity listed in tables I and II can be attributed to subjective variations which frequently occur when subjects are re-tested on the Orthorater.

Some additional observations about the men who remained in the chamber for 10 minutes (table III) should be mentioned. These men were selected by psychologists as part of another study to determine how some men are able to tolerate high concentrations of CS. Many volunteers remained in the chamber for 10 minutes in spite of considerable distress. Most volunteers opened their eyes only when they were required to read the chart or to locate the exit door. Volunteer 13, however, kept his eyes open during the entire exposure and unhesitatingly read the 20/20 letters from the chamber. Those who could keep their eyes open long enough generally read the 20/20 letters. Therefore, it is possible that many of the volunteers who read less than 20/20 might have had better visual acuity if they could have kept their eyes open longer. At high concentrations eye irritation appeared to be greater than at low concentrations. For example, when volunteer 22 was asked to open his eyes and read the letters, he quickly closed his eyes and moved towards the exit door indicating he wished to terminate the test. He later admitted that he had not opened his eyes during the entire time he was in the chamber, and when he did open them to read the chart, the irritation was intolerable.

V. CONCLUSIONS.

The results of this study indicate that there is no appreciable change in visual acuity after exposure to CS. During exposure to low concentrations all subjects can, with considerable effort, open their eyes for a few seconds. Their visual acuity decreases slightly during exposure to concentrations higher than 5.0 mg/cu m eye irritation is intense and most subjects cannot keep their eyes open for even a few seconds.

August 1968
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